(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 013 293 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.06.2000 Bulletin 2000/26

(51) Int. Cl.[7]: A61M 1/00

(21) Application number: 99106796.8

(22) Date of filing: 06.04.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 22.12.1998 JP 37640298

(71) Applicant: Kawamura, Akio
Sapporo-shi (JP)

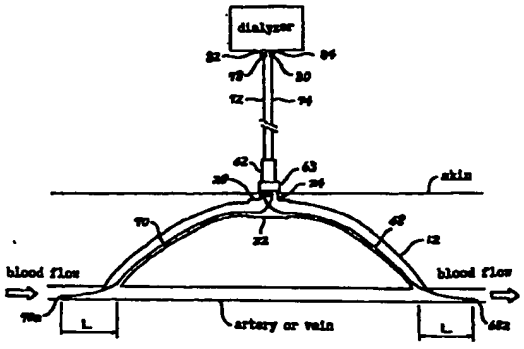
(72) Inventor: Kawamura, Akio
Sapporo-shi (JP)

(74) Representative:
Diehl, Hermann, Dr. Dipl.-Phys. et al
DIEHL, GLÄSER, HILTL & PARTNER
Patentanwälte
Augustenstrasse 46
80333 München (DE)

(54) No-needle blood access device for hemodialysis and no-needle connecting cannula assembly

(57) A no-needle blood access device (10) for hemodialysis comprising, an artificial conduit (12) whose opposite ends are anastomosed to a targeted artery or vein; a metallic body (20), the body including a cylindrical horizontal portion (22) covering the entire circumference of the conduit or an arcuate-shaped horizontal portion covering at least an upper half of the circumference of the conduit, and a cylindrical vertical portion (24) connected to approximately the center of the upper part of the horizontal portion so as to be disposed perpendicular to the horizontal portion and defining a well (26) therein, the horizontal portion being provided at the part located at the bottom of the well with a first pair of apertures (30, 32), the conduit being provided at the corresponding part with a second pair of apertures (30, 32), whereby the well is in communication with the conduit through the apertures; and a pair of shutters (34, 36) slidably housed within opposed pockets formed in the upper part of the horizontal portion respectively and arranged such that they can be opened and closed; whereby the device is arranged such that, when the shutters are opened, the well is brought into communication with the conduit, and when the shutters are closed, the well is brought out of communication with the conduit.

FIG. 8



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Description

[0001] The present invention generally relates to a no-needle blood access device for hemodialysis and a no-needle connecting cannula assembly.

[0002] Hemodialysis is used widely as a remedy for treating kidney insufficiency. In many cases, a surgical short circuit which is commonly referred to as "shunt" is implanted in a blood vessel or blood vessels of the patient suffering from serious kidney disease, because such a patient must receive hemodialysis treatment periodically over a long period of time. Shunts are divided broadly into two categories, an internal shunt and an external shunt. The internal shunt has a drawback that needle puncture is required during hemodialysis. On the other hand, the external shunt has a high rate of thrombosis and infection, and makes daily life more inconvenient.

[0003] To overcome these drawbacks of the prior shunts, a new blood access device for hemodialysis has been proposed. The blood access device given the tradename "Hemasite" conceptually belongs to the external shunt group. The Hemasite blood access device is equipped with a tool that has a back-flow valve for blood, and is adapted to acquire a plentiful blood flow immediately if the tool is simply connected to a circuit leading to a dialyzer. This Hemasite blood access device has an advantage that needle puncture is not required, but due to its complicated structure, is costly and troublesome to handle.

[0004] On the other hand, presently, a circuit for connecting the blood access devices implanted in human bodies to a dialyzer during hemodialysis consists of tubes each having a relatively large diameter, and each of these tubes is short, because the amount of blood circulating outside the body of the patient has to be reduced so as not to load the human body. This is due to the reason that the amount of blood circulating outside the body of the patient becomes large if the circuit is made of long tubes with a large diameter. Accordingly, if the prior circuit is used to hemodialyze, the patient cannot move about freely and must lie on a bed quietly, during hemodialysis.

[0005] It is, therefore, the object of the present invention to overcome the drawbacks of the prior art. This object is solved by the no-needle blood access device according to the independent claim 1 and the no-needle connecting cannula assembly according to the independent claim 6. Further advantageous features, aspects and details of the invention are evident from the dependent claims, the description and the drawings. The claims are to be understood as a first non-limiting approach to define the invention in general terms.

[0006] The present invention relates to a no-needle blood access device for hemodialysis with a mechanism of simple structure, as well as a no-needle connecting cannula assembly which enables a patient to move around with relative freedom during hemodialysis.

[0007] It is, therefore, an aspect of the present invention to provide a blood access device for hemodialysis which does not require needle puncture, and which has a mechanism of simple structure, and which can be advantageously manufactured at a relatively low cost, and which is easy to handle, as well as a no-needle connecting cannula assembly which enables a patient to move around with relative freedom during hemodialysis.

[0008] The above and other aspects of the present invention can be accomplished by a no-needle blood access device for hemodialysis comprising, an artificial conduit whose opposite ends are anastomosed to a targeted artery or vein; a metallic body, the body including a cylindrical horizontal portion covering the entire circumference of the conduit or an arcuate-shaped horizontal portion covering at least an upper half of the circumference of the conduit, and a cylindrical vertical portion connected to approximately the center of the upper part of the horizontal portion so as to be disposed perpendicular to the horizontal portion and defining a well therein, the horizontal portion being provided at the part located at the bottom of the well with a first pair of apertures, the conduit being provided at the corresponding part with a second pair of apertures, whereby the well being in communication with the conduit through the apertures; and a pair of shutters slidably housed within opposed pockets formed in the upper part of the horizontal portion respectively and arranged such that they can be opened and closed; whereby the device is arranged such that, when the shutters are opened, the well is brought into communication with the conduit, and when the shutters are closed, the well is brought out of communication with the conduit.

[0009] Further, the above and other aspects of the present invention can be advantageously accomplished by a no-needle connecting cannula assembly for hemodialysis comprising, a cap provided with a pair of through-holes; a first pair of cannulas connected to one end of the through-holes respectively so as to be in communication with the corresponding through-holes, the external diameter of the respective leading ends of the cannulas being selected to be slightly smaller than the diameter of the apertures, the external diameter of the respective ends of the side of the cannulas to which the cap is connected being selected to be slightly larger than the diameter of the apertures; and a second pair of cannulas connected to the other end of the through-holes respectively so as to be in communication with the corresponding through-holes and adapted to define a connecting circuit leading to a dialyzer, the second pair of cannulas having an internal diameter approximately equal to the internal diameter of each of the first pair of cannulas, the second pair of cannulas being at least 3 meters in length, one of the second pair of cannulas being provided at an end proximal to the dialyzer with a terminal for connecting to a terminal of the dialyzer, the other of the second pair of cannulas being provided at an end proximal to the dialyzer with a terminal for con-

necting to a terminal of the dialyzer.

[0010] In a preferred aspect of the present invention, each of the shutters of the no-needle blood access device for hemodialysis is provided at their opposite ends with upwardly extending projection pieces respectively, and the projection pieces serve as a knob during the opening and closing of the shutters.

[0011] In another preferred aspect of the present invention, one of the projection pieces of the no-needle blood access device for hemodialysis is formed to be higher than the other.

[0012] In a further preferred aspect of the present invention, each of the projection pieces of the no-needle blood access device for hemodialysis is mounted on the shutters respectively so that one of the projection piece shifts slightly with respect to the other in a horizontal direction along those ends.

[0013] In a further preferred aspect of the present invention, the end of the first shutter of the no-needle blood access device facing the second shutter is provided with a recess or a stepped part, and the end of the second shutter facing the first shutter is provided with a projection or a stepped part adapted to mate with the recess or the stepped part when the shutters are closed.

[0014] In a further preferred aspect of the present invention, the first pair of cannulas of the connecting cannula assembly curve so that the curvature becomes larger from the end proximal to the cap towards the end distal to the cap.

[0015] In a further preferred aspect of the present invention, the first pair of cannulas of the connecting cannula assembly curve so that the curvature becomes larger from the end proximal to the cap towards the end distal to the cap and intersects at a location adjacent to the end proximal to the cap.

[0016] In a further preferred aspect of the present invention, when each of the first pair of cannulas is inserted from the apertures of the body of the blood access devices for hemodialysis through the artificial conduit into the targeted artery or vein, the length of each of the first pair of cannulas of the connecting cannula assembly is selected so that the distance between the anastomosis area of the artificial conduit to the targeted artery or vein and the respective leading ends of the first pair of cannulas is about 3 centimeters.

[0017] The above and other aspects and features of the present invention will become apparent from the following description made with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a no-needle blood access device for hemodialysis of a preferred embodiment of the present invention which is implanted in a human body.

Figure 2 is an enlarged sectional view of a body of the no-needle blood access device for hemodialysis of Figure 1.

Figure 3A is an enlarged sectional view of abutting parts of shutters of the no-needle blood access device for hemodialysis of Figure 1.

Figure 3B is an enlarged sectional view of another version of abutting parts of shutters of the no-needle blood access device for hemodialysis of Figure 1.

Figure 4A is a perspective view of projection pieces of the shutters of the blood access device.

Figure 4B is a perspective view of another version of projection pieces of the shutters of the blood access device.

Figure 5 is a cross sectional view taken along line 5-5 in Figure 2.

Figure 6 is a view similar to Figure 5 showing another version of a horizontal portion of the body of the blood access device.

Figure 7A is a diagrammatic view of a first embodiment of a no-needle connecting cannula assembly of the present invention.

Figure 7B is a diagrammatic view of a second embodiment of the no-needle connecting cannula assembly of the present invention.

Figure 7C is a diagrammatic view of a third embodiment of the no-needle connecting cannula assembly of the present invention.

Figure 8A is a cross sectional view showing a first pair of cannulas of the no-needle connecting cannula assembly of the present invention.

Figure 8B is a cross sectional view showing another version of the first pair of cannulas of the no-needle connecting cannula assembly of the present invention.

Figure 9 is a diagrammatic view showing the condition wherein the no-needle blood access device and the no-needle connecting cannula assembly of the present invention are used to hemodialyze.

Figure 10 is an enlarged sectional view of the body of the no-needle blood access device of Figure 9.

[0018] The preferred embodiments of the present invention will now be explained with reference to the accompanying drawings. A no-needle blood access device for hemodialysis generally indicated by a reference numeral 10 in Figure 1 which is an embodiment of the present invention comprises a metallic body 20. The body 20 includes a cylindrical horizontal portion 22 and a cylindrical vertical portion 24 connected to approximately the center of the upper part of the horizontal portion 22 so as to be disposed perpendicular to the horizontal portion 22. The vertical portion 24 defines a well 26 therein. The body 20 is generally an inverted T-shaped, as viewed from the side, as shown in Figure 1.

[0019] Preferably, the body 20 is made from titanium which is light and biocompatible, and the part of the body 20 with which blood comes into contact is covered with pyrolitic carbon which is an anticoagulant substance. Further, preferably, the external surface of each

of the horizontal portion 22 and the vertical portion 24 is covered with a biocompatible fiber 28 such as dacron velour in order to enhance the fusion with human tissue and provide a barrier to bacteria invading from the outside.

[0020] An artificial conduit 12 is passed into the horizontal portion 22 of the body 20. The artificial conduit 12 is prevented from moving inside the horizontal portion 22, because the horizontal portion 22 is formed so that the internal diameter is substantially equal to the external diameter of the artificial conduit 12, and adhesive (not shown) is applied on the area between the internal surface of the horizontal portion 22 and the external surface of the artificial conduit 12. The adhesive applied on the area between the internal surface of the horizontal portion 22 and the external surface of the artificial conduit 12 may be advantageously biocompatible.

[0021] As best shown in Figure 2, a pair of apertures 30 and 32 each having a diameter of D1 are provided at the part of the horizontal portion 22 located at the bottom of the well 26 and the corresponding part of the artificial conduit 12 respectively, whereby the well 26 is in communication with the artificial conduit 12 through the apertures 30 and 32.

[0022] The body 20 further includes a pair of shutters 34 and 36 for bringing the well 26 out of communication with the artificial conduit 12. Each of the shutters 34 and 36 is housed within opposed pockets 38 and 40 formed in the upper part of the horizontal portion 22 respectively, and is arranged such that they can be opened and closed. More specifically, as shown in Figure 2, the horizontal portion 22 is provided at locations facing the well 26 of the upper part with the pockets or recesses 38 and 40 respectively, and each of the plate-shaped shutters 34 and 36 is received in a sliding manner within the pockets 38 and 40 respectively. Each of the shutters 34 and 36 is provided at their opposite ends with upwardly extending projection pieces 42 and 44 respectively. Each of the projection pieces 42 and 44 serves as a knob during the opening and closing of the shutters 34 and 36. As shown in Figure 2, the surface of the projection piece 42 facing the projection piece 44 is adapted to abut on the surface of the projection piece 44 facing the projection piece 42 when the shutters 34 and 36 are closed.

[0023] Preferably, as shown in Figure 3A, the end of the shutter 34 facing the shutter 36 is provided with a recess 34a, and the end of the shutter 36 facing the shutter 34 is provided with a projection 36a which is adapted to mate with the recess 34a when the shutters 34 and 36 are closed. Alternatively, instead of the recess 34a and the projection 36a, as shown in Figure 3B, the end of the shutter 34 facing the shutter 36 may be provided with a stepped part 34b, while the end of the shutter 36 facing the shutter 34 may be provided with a stepped part 36b adapted to mate with the stepped part 34b when the shutters 34 and 36 are closed. According to the construction, it is possible to bring the well 26 out of communication with the artificial conduit 12 completely when the shutters 34 and 36 are closed.

[0024] Figures 4A and 4B show two preferred embodiments of the projection pieces 42 and 44. In the preferred embodiment shown in Figure 4A, the projection piece 42 is formed to be higher than the projection piece 44. On the other hand, in the preferred embodiment shown in Figure 4B, each of the projection pieces 42 and 44 are mounted on the shutters 34 and 36 respectively so that the projection piece 42 shifts slightly with respect to the projection piece 44 in a horizontal direction along those ends. Alternatively, one projection piece (not shown) may preferably be formed so that the width is larger than that of the other projection piece(not shown). According to these constructions, when the shutters 34 and 36 are to be opened and closed by a tool such as a pincette, it is easy to grasp them with the tool.

[0025] As shown in Figure 2, the projection pieces 42 and 44 may be, advantageously, secured with respect to each other by a clip 46 to prevent the shutters 34 and 36 from opening when they are closed. Further, the top of the vertical portion 24 may be covered with a cap 48 to cover up the well 26 when the blood access device 10 is not in use.

[0026] Figure 5 shows a cross section taken along line 5-5 in Figure 2. In the embodiment shown in Figure 5, the horizontal portion 22 covers the entire circumference of the artificial conduit 12. However, as shown in Figure 6, the horizontal portion may also be alternatively formed to cover only a part of the circumference of the artificial conduit 12. The horizontal portion 22 shown in Figure 6 is arcuate-shaped in cross section, of which the lower part is cut out, so that the lower part of the artificial conduit 12 is exposed. The exposed part 12a of the artificial conduit 12 corresponds to their lower half at most. In other words, the angle α shown in Figure 6 ranges from 0° to 180°. As described later in detail, both the body 10 and the artificial conduit 12 are placed in the human body of the patient. Therefore, according to the construction shown in Figure 6, a feeling of physical discomfort which may tend to be caused when the rigid metallic body 10 comes into contact with the body tissue directly, is reduced.

[0027] A preferred no-needle connecting cannula assembly for connecting the no-needle blood access device 10 to a dialyzer during hemodialysis will now be explained. A no-needle connecting cannula assembly generally indicated by a reference numeral 60 in Figure 7A which is a first embodiment of the assembly of the present invention comprises a cap 62 provided with a pair of through-holes 64 and 66, a first pair of cannulas 68 and 70 connected to one end of the through-holes 64 and 66 respectively so as to be in communication with the through-holes 64 and 66, and a second pair of cannulas 72 and 74 connected to the other end of the

through-holes 64 and 66 respectively so as to be in communication with the through-holes 64 and 66, as best shown in Figure 10. The cannulas 68, 70, 72 and 74 are preferably made of a conventional flexible material, and the cap 62 is advantageously made of a plastic material.

[0028] The cap 62 is mounted with a box nut 63 for securing the body 20 of the blood access devices 10 to the cap 62 during hemodialysis, as described later.

[0029] Each of the cannulas 68 and 70 is a tube adapted to be inserted from the apertures 30 and 32 respectively through the artificial conduit 12 into the targeted artery or vein. The external diameter D2 of the respective leading ends 68a and 70a of the cannulas 68 and 70 (or, the respective ends opposite the side of the cannulas 68 and 70 to which the cap 62 is connected) is selected to be slightly smaller than the diameter D1 of the apertures 30 and 32 to facilitate the insertion of the cannulas 68 and 70 into the apertures 30 and 32 respectively. The external diameter D3 of the respective ends 68b and 70b of the side of the cannulas 68 and 70 to which the cap 62 is connected is selected to be slightly larger than the diameter D1 of the apertures 30 and 32 to avoid the leakage of blood during hemodialysis. From the foregoing, the relationship among the the diameters D1, D2 and D3 can be expressed as follows: $D2<D1<D3$.

[0030] As shown in Figure 7A, the cannula 68 curves so that the curvature becomes larger from the end 68b towards the end 68a, and intersects at a location adjacent to the end 68b. The cannula 70 also curves so that the curvature becomes larger from the end 70b towards the end 70a, and intersects at a location adjacent to the end 70b. The cannulas 68 and 70 may be provided with a spacer member 76 for holding the spacing between the cannulas 68 and 70 at a location adjacent to the ends 68b and 70b. Thereby the insertion of the cannulas 68 and 70 into the artery or the vein can be effected smoothly.

[0031] The cannulas 72 and 74 are tubes adapted to define a connecting circuit leading to the dialyzer, and each of them has an internal diameter approximately equal to the internal diameter of each of the cannulas 68 and 70. The cannula 72 is provided at the end 72 proximal to the dialyzer with a terminal 78 for connecting to a terminal 82 of the dialyzer. The cannula 74 is also provided at the end 74a proximal to the dialyzer with a terminal 80 for connecting to a terminal 84 of the dialyzer. Each of the terminals 78 and 80 may be a conventional screw type terminal. Each of the cannulas 72 and 74 has a length (at least 3 meters) sufficient for the patient to move around with relative freedom during hemodialysis. Since the internal diameter of each of the cannulas 72 and 74 is selected to be approximately equal to that of each of the cannulas 68 and 70 as described above, the length of each of the cannulas 72 and 74 can be increased without increasing the amount of blood circulating outside the body of the patient.

[0032] The cannulas 72 and 74 may consist of either two separate tubes as shown in Figure 8A, or one tube in appearance which is made by combining two tubes as shown in Figure 8B.

[0033] A no-needle connecting cannula assembly generally indicated by a reference numeral 86 in Figure 7B which is a second embodiment of the assembly of the present invention is substantially similar to the assembly 60 except that the cannulas 68 and 70 do not intersect at the location adjacent to the ends 68b and 70b.

[0034] Further, a no-needle connecting cannula assembly generally indicated by a reference numeral 88 in Figure 7C which is a third embodiment of the assembly of the present invention is substantially similar to the assembly 86 except that each of the cannulas 68 and 70 do not curve.

[0035] The thus constituted no-needle blood access device for hemodialysis 10 and no-needle connecting cannula assembly 60 operates as follows. Firstly, as shown in Figure 1, the body 20 is implanted in a desired area of the upper arm, etc. of the patient and the artificial conduit 12 is anastomosed to the targeted artery or vein. When it is to be hemodialyzed, the cap 48 is removed from the body 20, and then the clip 46 is taken off from the shutters 34 and 36 to open them by a tool such as a pincette. Thereafter, as shown in Figure 9, each of the cannulas 68 and 70 of the no-needle connecting cannula assembly 60 which is connected to the dialyzer is inserted from the apertures 30 and 32 of the body 20 through the artificial conduit 12 into the targeted artery or vein respectively. Then, as shown in Figure 9, it is desirable that the distance L between the anastomosis area of the artificial conduit 12 to the artery or vein and the respective leading ends 68a and 70a of the cannulas 68 and 70 is about 3 centimeters. It is necessary to tighten the box nut 63 to prevent the cap 62 from being removed from the body 20. When hemodialysis is completed, each of the cannulas 68 and 70 is withdrawn, and the shutters 34 and 36 are closed and secured by the clip 46, and then, the top of the vertical portion 24 is covered with the cap 48. The used assembly 60 may be discarded.

[0036] The present invention has thus been shown and described with reference to specific embodiments. However, it should be noted that the present invention is in no way limited to the details of the described arrangements but changes and modification may be made without departing from the scope of the appended claims.

[0037] For example, although the vertical portion of the body is shown as having a cylindrical shape in the above described embodiments, they may have other shapes. Further, although the artificial conduit is anastomosed to the same artery or vein in the above described embodiments, each end of the artificial conduit may be anastomosed to separate arterys or veins.

[0038] Further, the no-needle connecting cannula assembly 60 is explained in relation to its use together

with the no-needle blood access device 10. However, the no-needle connecting cannula assembly 60 may be used with other types of external shunts.

[0039] According to the present invention, since the body has a simple structure, the blood access device for hemodialysis which does not require needle puncture and can be manufactured at a relatively low cost and is easy to handle, is provided. Further, by using the no-needle connecting cannula assembly of the present invention, the patient can move around with relative freedom during hemodialysis.

Claims

1. A no-needle blood access device (10) for hemodialysis comprising:

   an artificial conduit (12) whose opposite ends are anastomosed to a targeted artery of vein;

   a metallic body (20), the body including a cylindrical horizontal portion (22) covering the entire circumference of the conduit (12) or an arcuate-shaped horizontal portion covering at least an upper half of the circumference of the conduit (12), and a cylindrical vertical portion (24) connected to approximately the center of the upper part of the horizontal portion (22) so as to be disposed perpendicular to the horizontal portion (22) and defining a well (26) therein, the horizontal portion (22) being provided at the part located at the bottom of the well (26) with a first pair of apertures (30, 32), the conduit (12) being provided at the corresponding part with a second pair of apertures (30, 32), whereby the well (26) is in communication with the conduit (12) through the apertures (30, 32); and

   a pair of shutters (34, 36) slidably housed within opposed pockets (38, 40) formed in the upper part of the horizontal portion respectively and arranged such that they can be opened and closed;

   whereby the device is arranged such that, when the shutters (34, 36) are opened, the well (26) is brought into communication with the conduit (12), and when the shutters (34, 36) are closed, the well (26) is brought out of communication with the conduit (12).

2. A no-needle blood access device for hemodialysis in accordance with claim 1 wherein, each of the shutters (34, 36) is provided at their opposite ends with upwardly extending projection pieces (42, 44) respectively, the projection pieces (42, 44) serving as a knob during the opening and closing of the shutters (34, 36).

3. A no-needle blood access device for hemodialysis in accordance with claim 2 wherein, one of the projection pieces (42, 44) is formed to be higher than the other.

4. A no-needle blood access device for hemodialysis in accordance with claim 2 or 3 wherein, each of the projection pieces (42, 44) is mounted on the shutters (34, 36) respectively so that one of the projection pieces shifts slightly with respect to the other in a horizontal direction along those ends.

5. A no-needle blood access device for hemodialysis in accordance with any one of claims 1 to 4 wherein, the end of the first shutter (34) facing the second shutter (36) is provided with a recess (34a) or a stepped part (34b), and the end of the second shutter (36) facing the first shutter (34) is provided with a projection (36a) or a stepped part (36b) adapted to mate with the recess or the stepped part when the shutters are closed.

6. A no-needle connecting cannula assembly (60, 86, 88) for hemodialysis comprising:

   a cap (64) provided with a pair of through-holes (64, 66);

   a first pair of cannulas (68, 70) connected to one end of the through-holes respectively so as to be in communication with the corresponding through-holes, the external diameter (D2) of the respective leading ends (68a, 70a) of the cannulas (68, 70) being selected to be slightly smaller than the diameter (D1) of the apertures (30, 32), the external diameter (D3) of the respective ends (68b, 70b) of the side of the cannulas (68, 70) to which the cap (62) is connected being selected to be slightly larger than the diameter (D1) of the apertures (30, 32); and

   a second pair of cannulas (72, 74) connected to the other end of the through-holes (64, 66) respectively so as to be in communication with the corresponding through-holes and adapted to define a connecting circuit leading to a dialyzer, the second pair of cannulas (72, 74) having an internal diameter approximately equal to the internal diameter of each of the first pair of cannulas (68, 70), the second pair of cannulas (72, 74) having at least 3 meters in length, one (72) of the second pair of cannulas being provided at an end (72) proximal to the dialyzer with a terminal (78) for connecting to a terminal (82) of the dialyzer, the other (74) of the second pair of cannulas being provided at an end prox-

imal to the dialyzer with a terminal (80) for connecting to a terminal (84) of the dialyzer.

7. A no-needle connecting cannula assembly in accordance with claim 6 wherein, the first pair of cannulas (68, 70) curve so that the curvature becomes larger from the end (68b, 70b) proximal to the cap (62) towards the end (68a, 70a) distal to the cap (62).

8. A no-needle connecting cannula assembly in accordance with claim 6 wherein, the first pair of cannulas (68, 70) curve so that the curvature becomes larger from the end (68b, 70b) proximal to the cap (62) towards the end (68a, 70a) distal to the cap (62) and intersects at a location adjacent to the end (68b, 70b) proximal to the cap (62).

9. A no-needle connecting cannula assembly in accordance with any one of claims 6 to 8 wherein, when each of the first pair of cannulas (68, 70) is inserted from the apertures (30, 32) of the body (20) of the blood access devices (10) for hemodialysis through the artificial conduit (12) into the targeted artery or vein, the length of each of the first pair of cannulas (68, 70) is selected so that the distance between the anastomosis area of the artificial conduit (12) to the targeted artery or vein and the respective leading ends (68a 70a) of the first pair of cannulas (68, 70) is about 3 centimeters.

FIG. 1

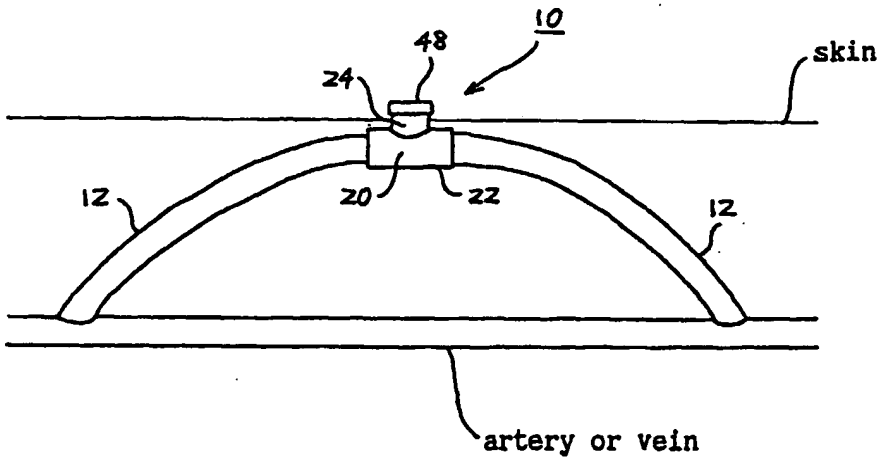


FIG. 2

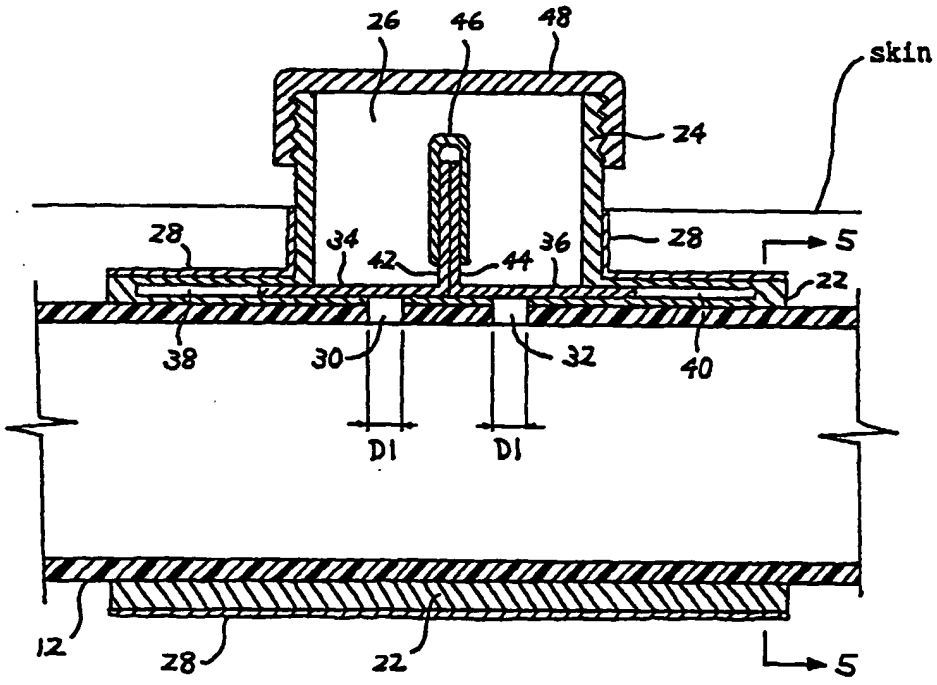


FIG. 3A

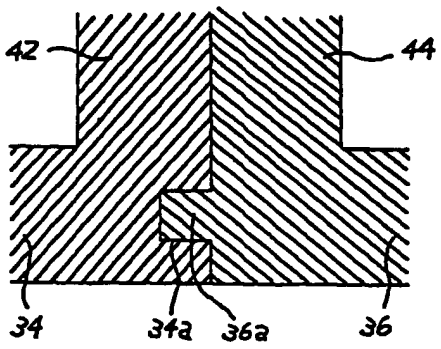


FIG. 3B

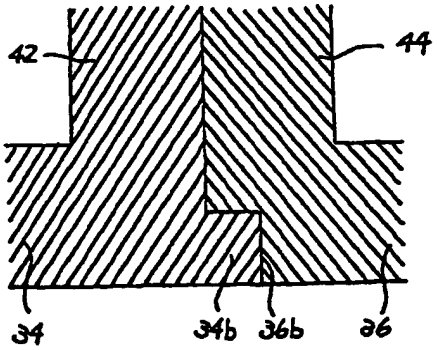


FIG. 4A

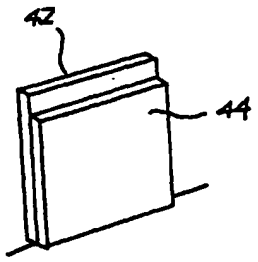


FIG. 4B

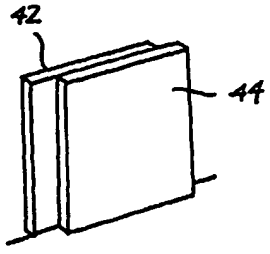


FIG. 5

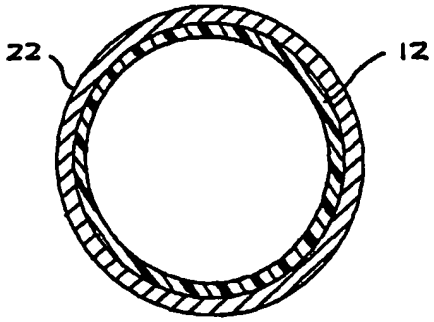


FIG. 6

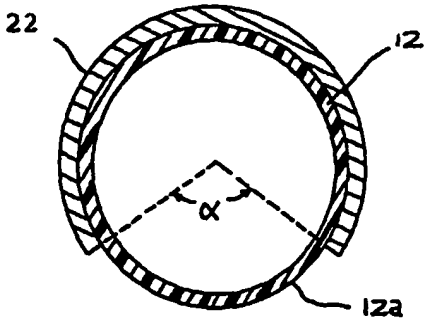


FIG. 7A

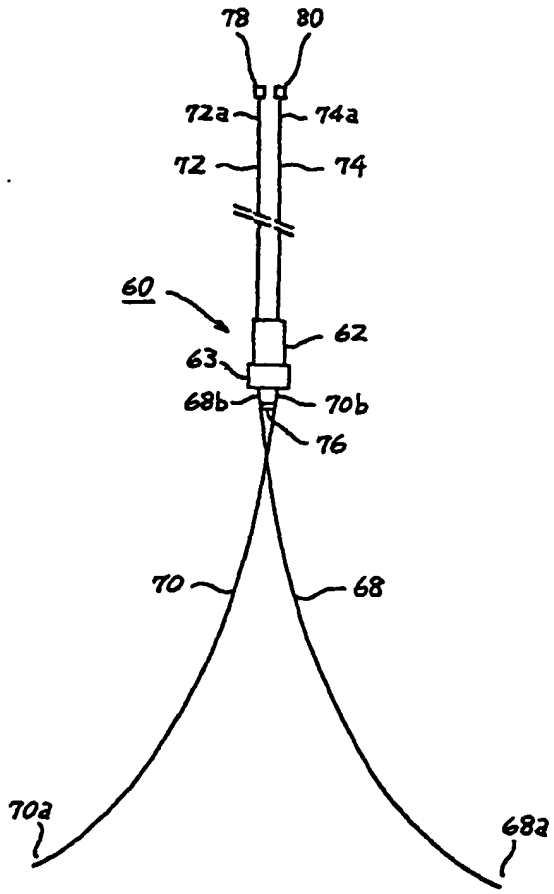


FIG. 7B

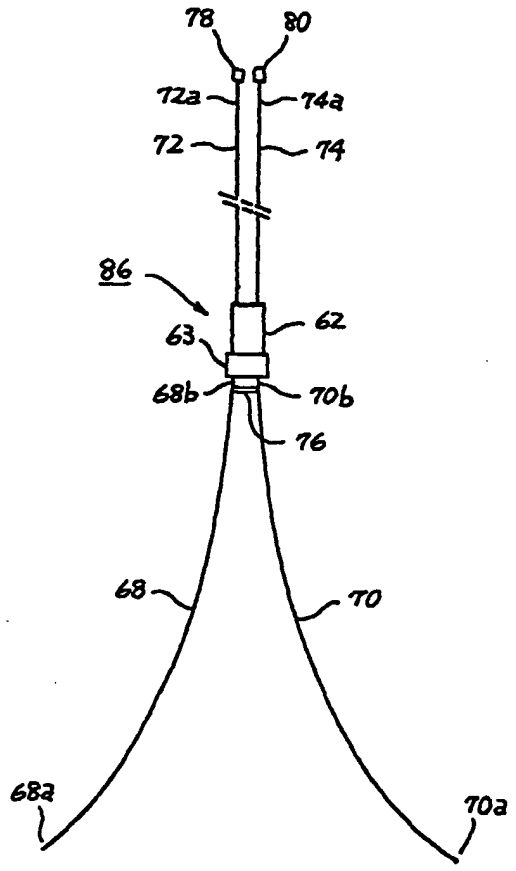


FIG. 7C

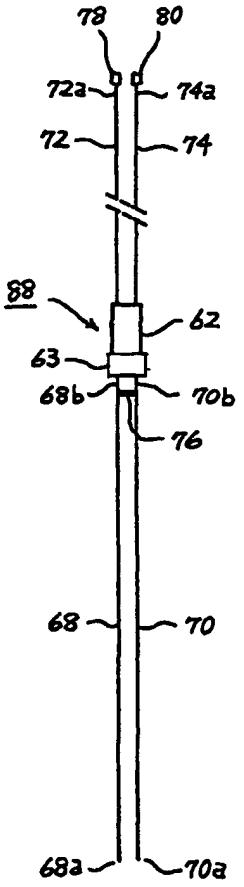


FIG. 8A

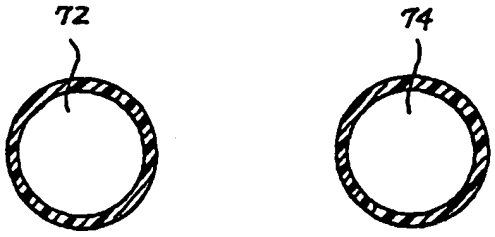


FIG. 8B

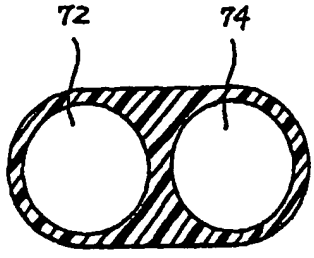


FIG. 9

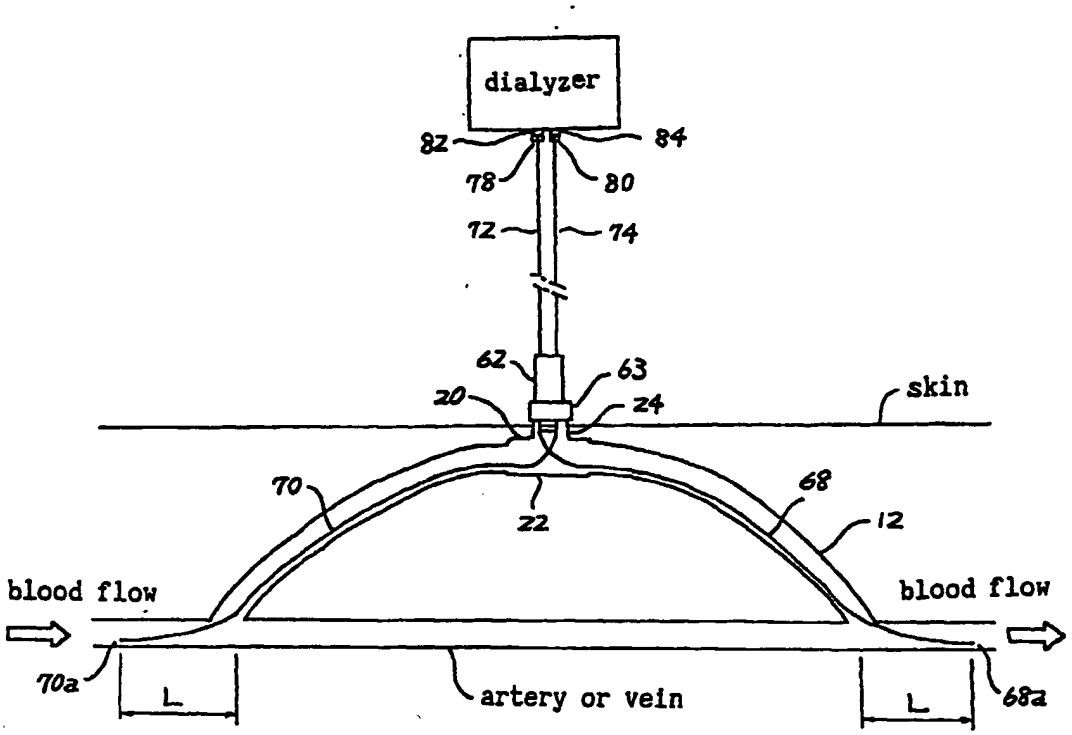
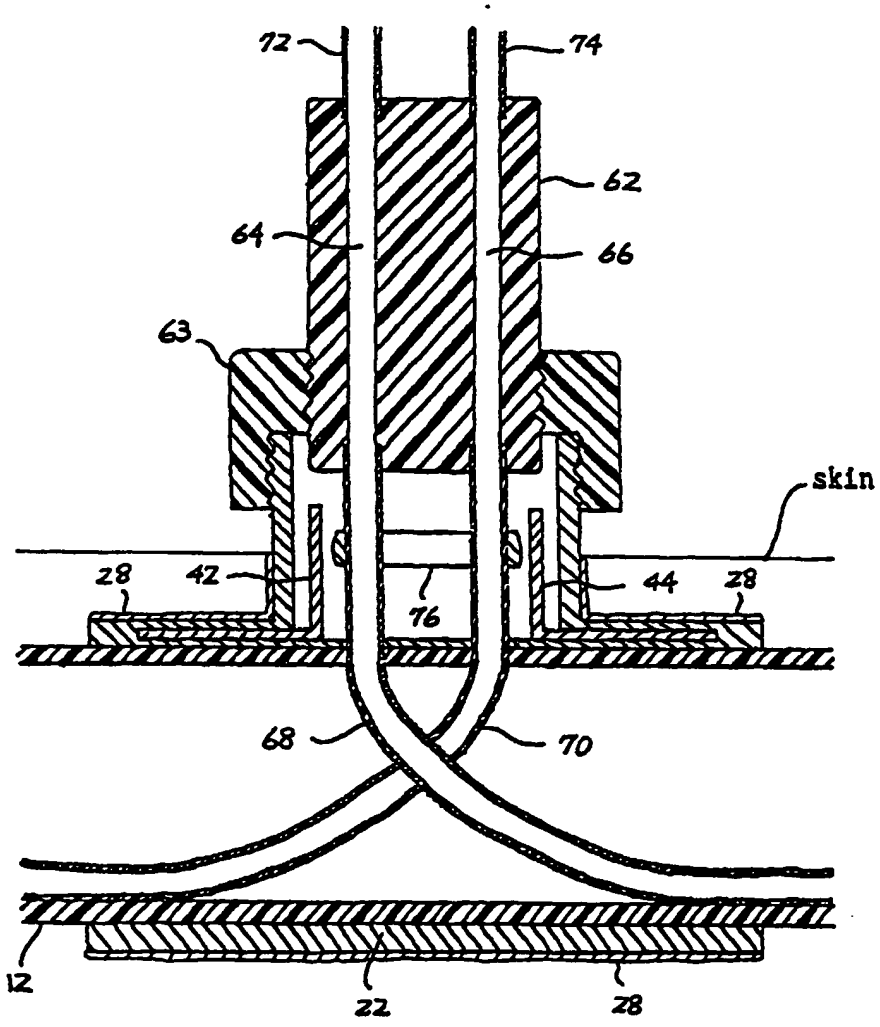

dialyzer
82
84
78
80
72
74
62
63
20
24
skin
70
68
22
12
blood flow
blood flow
70a
L
artery or vein
L
68a

FIG. 10



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Application Number
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Place of search	Date of completion of the search	Examiner
THE HAGUE	24 March 2000	Levert, C

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